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THE LARGER PHYSIOGRAPHIC FEATURES OF NEW YORK

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IN its physiographic features New York State presents a number of distinct provinces, forming a combination of surface forms which has given rise to very varied industry, and which has helped to guide the development of the state to its present high rank. The different provinces have influenced this development to different degrees and in different ways, but all have had some bearing upon the growth of the state. A part of the importance of New York is to be found in its own geographic condition, and a part in its position on a highway of travel from the interior to the coast.

One of the largest of the physiographic provinces of New York State is the plateau belt that extends from the western margin of the Hudson valley westward completely across the state and southward to and beyond the Pennsylvania boundary. This plateau area is but a northern extension of the Alleghany plateau which fringes the western base of the Appalachian Mountains. In New York State it reaches unusual height in the east, where its elevation and ruggedness have won for it the name Catskill Mountains. Here, as in other parts of the plateau, we have an upland formerly worn down to a state of low relief,—a stage of late maturity or early old age,—then uplifted and dissected into its present condition of late youth or early maturity. Remnants of the uplifted peneplain give rise to a rolling or slightly irregular upland surface which reminds one of the peneplain uplands of the Rhine region. Though the soil is thin, and often stony, and the markets are remote, these upland areas have commonly been cleared of forest and are occupied by farms and pastures. It is an important sheep and dairy region, but not the seat of high development of extensive agriculture. It is, and for several decades has been, a region of abandoned farm houses and of decreasing rural population.

Viewed from the valley bottoms the plateau region appears rugged and deeply dissected, while viewed from the uplands, away from the valley margins, it has the appearance of a rolling country. The steep slopes of the valleys, and in some cases even the hilltops, support so much forest that this plateau region is one which still supplies a consider-

able amount of lumber, particularly in the more rugged portions, as in the Catskills. Many of the valleys are too narrow for farming, but the larger valleys, oftentimes floored with glacial deposits or with outwash gravels, have become the seat of a prosperous agricultural population.

Nowhere is this plateau region densely settled, and in the main settlement is sparse; but owing to the fact that railway systems have been built across the plateau along several lines, facilitating the transportation of coal from the neighboring state of Pennsylvania, industries have been encouraged which have led to the development of a few towns of moderate size, notably, Binghamton and Elmira. Owing to the lowering of divides by glacial erosion, it has been possible for cross lines of railway to be built from the large valley of the south—the Susquehanna—northward across the plateau. There is, therefore, a fair provision for transportation but no real incentive for dense population; and, in spite of the value of the anthracite coal, even the trunk lines of railway have not taken highest rank among the great trunk lines. The region which these railways traverse is one of relative economic poverty, and the railroad grades are such as to make transportation expensive. Had it not been for the great coal deposits of the neighboring state of Pennsylvania it is quite probable that these trunk lines would not have been built, for the region itself has little to contribute. On the other hand, were it not for these trunk lines the plateau province would doubtless be much less densely settled than at present.

Ranking next in size to the plateau region, is the great Adirondack province of northern New York. This ancient mountain region of crystalline rock is in reality a prolongation into the United States of the Canadian province of the Laurentian Highlands. The mountains rise to an elevation of over a mile in the highest portion; the topography is rugged; the soil is thin; and the winter climate is severe. Those disadvantages have so interferred with industry that this is the most sparsely settled portion of the state. A large proportion of the surface is still a forest-covered wilderness,—an attractive center for health and pleasure resorts which constitute one of the chief uses of the Adirondack province. The forests, building stones and minerals, notably iron, contribute some raw materials for use mainly in the surrounding regions. The streams that descend from the mountain centers are fairly well supplied with water from the melting snows and the abundant rains, and they are well regulated by the forest cover and by the numerous lakes of glacial origin. In their rapid descent, especially where deflected by glacial deposits, these streams supply valuable water power which is utilized in a ring of towns surrounding the mountain base.

The Adirondacks are a roughly circular area of highland, and are therefore surrounded by a ring of lowland, a feature of great significance in the physiography of New York; for this lowland ring has become

the seat of improvement highways. To the west and north lies the Ontario-St. Lawrence highway; to the east the Champlain; to the south the Mohawk. These lowland areas tend to divert routes of travel, thus contributing to the sparseness of settlement of the Adirondack region, but tending to concentrate population in the lowland around its base.

The political accident of the location of the boundary line between Canada and United States along the St. Lawrence, and across the northern end of the Champlain highway in part explains the slight importance of these highway portions of the lowland ring; but is is also partly due to the comparative economic poverty of the region traversed, a land far to the north, with much rugged topography, and usually with a thin, stony soil. With free trade with Canada these routes might attain increased importance; and in the past periods of war they assumed high strategic importance, as they doubtless would again under similar conditions.

It is the southern portion of the lowland rim that ranks highest in geographic significance, for it is connected with the sea along the Hudson and with the interior United States along the Great Lakes. Entrance to the interior United States is defended by the Appalachian barrier, there being two natural water routes, one around the northern end of the mountain system along the St. Lawrence, and the other around the southern end, up the Mississippi. Between these two routes, while there are few if any places where railroads could not be built, there is no really good natural highay excepting that up the Hudson and Mohawk.

In central and northern New York the retreating escarpments of the nearly horizontal Paleozoic sedimentary strata of the Alleghany plateau form the southern slopes of a valley whose northern side is the crystalline Laurentian rocks of the Adirondacks and Canada. Lake Ontario and the Mohawk valley occupy portions of the site of this boundary lowland between two very different rock structures, and these provide a natural route to the interior essentially around the northern edge of the Alleghany plateau. The plateau-edge route swings southward along the eastern base of the Catskills, again essentially along the contact between two quite diverse geological structures—the nearly horizontal plateau rocks on the west, and the folded rocks of the New England mountains on the east.

Along this north-south line it happens that the Appalachian folded rocks are low—an extension of the Great Appalachian valley,—and that the crystalline rock area is both low and narrow. By normal stream erosion, modified by later glacial erosion, the Hudson has established a course across this low, narrow mountain belt; then, by subsidence admitting the tide above the Mohawk mouth, the trans-montane river course has become navigable.

This natural highway, early used and early impoved, is now one of the world's great arteries of commerce. By it the hinterground of New

York City is extended to the interior of the United States, both the Great Lakes and the Mississippi tributaries, with the plains between, becoming tributary to this outlet. This great artery from the west is joined by a smaller one from the north along the Champlain valley, and by many minor branches from New England and from the plateau province, each contributing its share to the vast trade that flows along this natural route.

While in New York State this highway is bordered for a large part of the way by regions of slight economic value, there are extensive areas of fertile and very productive agricultural land, notably in the valley lowland of the Hudson above the Highlands, and on the level lands of deep, fertile soil that fringe the southern shores of Lakes Erie and Ontario between the lakes and the plateau escarpment. Even these contribuiting agricultural areas, and the contribution of mineral and forest products from the state of New York itself, important though they are, form but a limited proportion of the basis for the industrial development along this highway. In other words, the state of New York, through which the artery extends, and in which it terminates, is but a very small portion of the great hinterground of the artery terminus at New York City.

A good, branching harbor at the mouth of the Hudson, a protected water route along the southern New England coast, and a lowland surface over which railroads may be built into New England and to the South have contributed to the flow of trade along this artery; while the broad open ocean, and especially the nearness to Europe as compared with cities further south, have given abundant opportunity for over sea traffic.

With such a remarkable highway, judging it from results, it is a fair question to ask whether we, as a people, have done with it as much as we should. Early enterprise, in recognition of the prospective value of this route, led to the building of the Erie Canal by the public; and private enterprise has given us an excellent system of railways. But in the meantime the Canadians, who share with us in the use of the Great Lakes, and who control their outlet river, thus having a rival highway, and a shorter one from interior United States to Europe, with wise foresight have been so improving their waterway that it is of great value, while ours is of almost negligible importance; and it is very doubtful if the barge canal expedient will give us a fair basis for competition.

If trade were free and undisturbed by the accident of political boundary lines, as many of us believe would be a better relationship between Canada and United States, as trade is free between New England and New York, it would be merely a matter of local importance whether trade flowed along the St. Lawrence to Montreal or along the Mohwak-Hudson route to New York. But now that the Canadians have indicated to us their intention to continue to make the boundary line of real commercial as well as of political significance, it becomes a question of national im-

portance whether we shall permit traffic to be diverted from the Mohawk-Hudson route. One way to prevent this diversion, and to increase the flow of trade along the artery, is to make adequate provision for water transportation from the lakes to the sea. It is my belief that this is one of the great present day needs in the industrial development of the United States. Physiographic processes have partially developed a remarkable highway from coast to interior, but have left the task for man to finish. Until a broad, deep canal is dug, admitting ocean boats to the Great Lakes, our part of the task will not be done.

THE AGRICULTURE OF NEW YORK

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THE agriculture of New York takes a front rank among the states of the Union in the value of its products, and in their wide diversity strongly reflect the physiographic features of the territory. The fact that out of a total population of nine million nearly six-sevenths is urban or semi-urban, may lead some persons to overlook the real agricultural importance of the state. It is worth while therefore to consider its agricultural status in several important respects. According to the Twelfth Census, New York stood fourth in the total value of agricultural products which amounted to two hundred and forty-five million dollars, —two-thirds the value of the leading state, Iowa. In 1899—the last authentic figures available—New York stood first in number of dairy cows and value of dairy products and was first in thirteeen other important products, including prominently hay and forage, potatoes, forest products, miscellaneous vegetables, beans, buckwheat, small fruits and nursery products, and was second in orchard products and grapes. It was first in the amount of money expended for farm labor, second in the total value of farm machiney and third in the value of fertilizers used.

New York state with its large agricultural production occupies a remarkably central position with reference to the large eastern centers of population and the centers of manufacturing and mining, all of which must be taken into consideration in estimating the states' agricultural worth. With an immense urban population distributed in the chief cities of New York, Buffalo, Rochester, Syracuse, and Albany, the state is also in direct and close communication with the cities of Boston, Philadelphia, Baltimore, Washington, Pittsburgh, and Cleveland, by the most direct transportation service available anywhere in American over the same territory, not to speak of the water connection by way of the Great Lakes and the St. Lawrence River with Canada, and by means of the in-

ternal canal, lake and river systems with the ocean and foreign ports.

Roughly speaking, one-third of rural New York is in forest and waste mountain land, one-third is in pasture and hay and one-third is devoted to all other cultivated crops.

Properly to appreciate the diversity of the agriculture of New York and the reason for the distribution of its chief products, one must understand the main outlines of the physiography of the state. For this the reader is referred to the preceding article by Professor R. S. Tarr.

THE SOIL.

The soil is the broad basal element which most determines the kind of crops grown and the type of farming business. Its influence is, of course, modified by climate, topography, transportation and markets. In few states, perhaps, does the agricultural development and evolution so closely follow soil distinctions. In this connection the soil is viewed broadly as a physical unit out of which crops and the farm business are made.

The soils of New York are of great variety due to the underlying geological structure of the state and the complicated processes by which these have been broken down and formed into soil material. All of the state with the exception of a small area in the southwestern part, chiefly in Cattaraugus county, has been over-run by glacial ice. It should be observed that the Adirondack section has a foundation chiefly of gneiss and granitic rocks with a fringe of limestone and sandstone on the west and south; that the eastern section is composed of extremely folded slates and quartzites with minor areas of limestone and other rocks, and that the southern New York plateau consists essentially of light colored non-calcareous shales and sandstone. South of the latitude of the Mohawk river and the Great Lakes, the successive geological formations outcrop under the unconsolidated material as a series of strips extending somewhat regularly across the state and in this series are two or three important strata of limestone which have had a large influence on the soils.

The glacial ice came in from a generally northern direction, deflected somewhat by the natural land forms, and advanced across these various rock formations and up the general slope of the country failing only in the small section of southwestern New York, noted above. Consequently, the higher hills were most lightly covered. The ice picked up much material, subsequently to be dropped further south in its course so that northern formations influenced the soils left on those rocks to the southward and a formation must be very extensive not to have its soil largely influenced by the introduction of material from some other formation. This fact also has largely determined the agricultural development of many sections, permitting the growth of some crops in certain sections and not in others.

(1) **Tarr, R. S. Physical Geography of New York State. p. 10.**

Alfalfa and beans in particular show this influence. The natural and continued success of clover also shows it. As the ice retreated it withdrew in a general way down the slope of the county in all the southern two-thirds of the state. Naturally the water from precipitation and the melting of the ice tended to be ponded into lakes between the front of the ice and the height of land. All the valleys contained at first small lakes and as the ice withdrew further these united through the valleys and low areas. Into these flowed streams ladened with sediment which was sorted and deposited. At different times the lower Genesee valley, the Seneca lake valley, and finally the Mohawk and St. Lawrence valleys were the general outlet. From Schenectady to Albany the great sand and gravel plain bespeaks the time when this great river emptied into a lake in that region. All the valleys leading south have rims of gravelly and sandy soils suggesting the time when they were filled to those levels by a raging river with perhaps a mass of dead ice in the center of the valley.

In the larger lakes sediments from the ice and the wash of the hills were sorted and deposited according to size, and form the extensive areas of stratified clay, sandy loam, loam and gravelly soils which generally characterize the less elevated portions of the state. Similar lakes of more limited extent occurred in northern and eastern New York especially through the Champlain valley and the upper central portion of the Hudson valley. Over the greater part of Long Island the material was deposited from New England and is exceedingly quartzose.

Not all of the lake plains area was covered by a lake and large rounded or rolling masses of glacial till are exposed to form in part the drumlin section east of Rochester. The plateau region has a soil of ice origin derived, on the hills, almost entirely from the local shale and sandstone rock. It is generally of a light color, heavy silt to clay texture, moderately stony and technically belongs largely in the Volusia series of soils. Certain types are characterized by a hardpan subsoil. Drainage is often defective; lime and humus are generally needed; clover now grows with difficulty where it formerly throve. This—especially certain hill types—is the marginal or so-called abandoned farm section. It is a region of farm readjustment.

The glacial soils vary markedly with the underlying rock. In the Hudson valley region they are very uneven and are often cut into small areas by outcropping masses of rock. This soil is much less uniform than in the plateau section or, in fact, any other agriculturally important part of the state. It is a region of extremes in soils. The higher lands in the Mohawk valley run to good quality with a fair supply of lime.

The lake formed soils are very diverse, especially in fineness. These with the true glacial soils of the Great Lakes region constitute the best of the agricultural sections of the state and are associated with several of the most important products.

RAINFALL AND ROADS

The rainfall of the state is greatest in the mountain section and across the Mohawk valley and decreases northwestward. The range is from about 25 to 60 inches with a mean of from 35 to 40 inches.

The wagon roads as well as other means of transportation bear an important relation to the topography and soils. There is a general state supported policy for road construction which gives preference to the main thoroughfares. The character and grade of secondary roads have a very important influence upon economic and social development in the hill sections which should never be overlooked in studying the agriculture of a region.

LEADING AGRICULTURAL PRODUCTS

With this hasty review of the physical features of the state the leading products may now be considered somewhat individually. *Hay and forage* have been pointed out as occupying first place in value of crops. Fifty-five million dollars, or more than one-third of the value of all farm crops are due to this product. It is widely grown throughout the state but the production is largest in the central portion centering on Madison and Chenango countries. It is also important through most of the plateau section of southern New York and on the heavy soils in the St. Lawrence valley. In general it is the clay land on the plains and in the valleys, and the hill lands, which have a heavy soil, on which the grass is produced.

Timothy is the dominant hay grass with clover generally seeded to some extent at the outset. But clover runs out naturally in two or three seasons and because of the large lack of lime in many sections of the state often scarcely makes a start. Red clover is also seriously affected by wet soil. In those sections in need of lime and drainage red top grass and Alsike clover is a more successful hay mixture. The average yield is one and a quarter tons and, considering the state as a whole, is a fairly consistent average.

The production of *wheat* is as large as formerly. A half-century ago wheat production in north central New York received much attention but seems to have been largely driven out by certain insects, and was kept out by changed economic conditions a little later. The lower Genesee valley region in northern Livingston county and the adjacent territory on the plain was the center of the production. In that part of the state in particular are large areas of soil suited to the crop—heavy loams and clay loams with surface to permit the use of machinery. The state is now eighteenth in rank and has a yield of 17.3 bushels per acre. (2)

(2) Bul. 9, N. Y. State Department of Agriculture. All statistics of acreage, yield and value are based upon the Twelfth Census and upon estimates of the U. S. Department of Agriculture for 1907.

Oats largely take the place of wheat in the rotation as compared with the system of farming in the east central states. This crop grows relatively well under the soil and climate conditions of the state. It serves as a nurse crop for grass and is in demand as a food for stock. It is third in total value in the state and the average yield is 30.7 bushels per acre. It is grown on all kinds of soil but especially upon those of the western and northern parts of the state of a heavy character.

Corn is widely grown. A large part is put into the silo. Flint varieties predominate for grain. Especially in the hill sections of southern New York and in the St. Lawrence valley is it made into ensilage because of the difficulty of maturing the crop. In total acreage for grain the state ranks very low. On the loam and gravelly soils of the southern New York valleys and in the vicinity of the lower valley of the Genesee river, it is used for grain production. The average yield is 27 bushels per acre.

The crops which have been enumerated afford the basis for the development of the *dairy industry*. These crops together with transportation conditions and markets seem to be the determining factor in the very extensive production of milk, butter and cheese in the central and northern sections of the state. The fact that these products are concentrated and that the manure of the animals is left on the farm to help keep up the fertility of the soil must not be overlooked. The value of dairy products is equal to that of the hay and forage. The industry is identified with certain soil and physiographic conditions and within these limits is modified by transportation conditions.

All of Southern New York west of the Catskills is about equally well suited to the dairy business but market milk is the dominant product and this closely follows the main lines of railroad within a certain radius of the cities. Special milk express trains are run into New York daily from Jefferson and St. Lawrence counties, three hundred miles away.

A number of special crops have a prominent place in the list of products. *Potatoes* stand first and give the state first rank in that crop, and in the state it has second place. They are produced widely over the state but most intensively in three general sections. First, as a part of the trucking business on Long Island, second, as a part of mixed farming south of Lake Ontario on the plain, and third, in the counties centering on Steuben county in the hill section of southern New York. In the first two regions they are given a place among the list of crops on the light loam and sandy loam soils. In the third region they attain relative prominence because they seem much better adapted to the soil and climate than other staple products. The cool summer, moist friable soil, and the deficiency of lime give a good yield of smooth potatoes of good quality when carefully handled. The average yield is nearly 100 bushels per acre.

The hill section of southern New York is all about equally well suited to the potato crop but it is most largely grown outside of the range of

milk production. However, it is often a money crop on the dairy farm and statistics collected by the State College of Agriculture suggest that some such money crop, as a side issue, may well be given a place on more dairy farms. (3)

Dry beans are a prominent crop along the northern slope of the plateau region south of Lake Ontario. Livingston, Monroe, Orleans, Genesee and Wyoming counties lead in their production. They thrive on the medium to heavy soils of that region which are moderately calcareous. The state has ranked first in bean production for several decades.

Cabbage is an important special crop in an area covering parts of several counties, situated east of the bean producing region. It is marketed directly or sold to kraut factories.

Alfalfa has long grown readily in certain limited sections of the state. Its favorite region has been a strip of country from a little east of Syracuse westward to Batavia and Attica with a width of from 15 to 30 miles. Here occur large areas of soils moderately well drained and, due to their relation to limestone strata and the processes of soil formation, have a good supply of lime. Similar conditions are found in small areas in other parts of the state but outside of these sections the growth of the crop demands especially careful treatment of the soil and on some types, especially the high hill lands, much success can not be promised even then. Under moderately favorable circumstances it will stand for from four to seven years and give from three to six tons per year. It is a valuable crop and worthy of careful attention for hay and forage.

The typical cereal on the poorer hill lands is *buckwheat* used both as a money crop and as a soil renovator and improver.

Apples are the leading tree fruit and are grown in the Ontario and upper Finger lake region on the loam and sandy loam soils. They are also grown in a much more limited way in the middle Hudson valley region on hill slaty loam soil. The four western counties bordering on Lake Ontario lead in apple products. Certain types of soil have proved especially favorable and a large and growing acreage has been developed. Because of the character of soil, chiefly, the nursery business has also been extensively developed in the same region.

Grapes are most grown west of the apple belt and seem to find their best situation along the steep forelands south of and facing Lake Erie. A smaller development of the crop has also occurred on similar soils along the western Finger Lakes.

Vegetables and farm wood-lot products represents antithesis in intensity of management of two important types of crop. The latter especially is widely distributed because nearly every farm has some land difficult to till which would better be devoted to forests. To forest products

(3) Bul. 295. An Agricultural Survey of Tompkins County. Cornell Expt. Sta.

very little attention has been given in the state. Many of the economic and social problems of the state which are extensively discussed simply represent the shift of certain disadvantaged or marginal areas from tilled farm land to forest purpose for which they are better suited.

CONCLUSION

The agriculture of New York is awakening to a new life. Production is being intensified. Prices are advancing. Social conditions in general are improving. The products are being diversified and better adapted to the soil, the market and the man. More drainage and better handling of the soil is coming in. And finally people—farmers—are coming into the state from the middle-west because now agricultural opportunities are relatively better in the east than in the west. The agriculture of New York is destined to hold her place near the front rank among the states of the Union.

THE ERIE CANAL

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THE great artificial waterway which connects Lake Erie with the Hudson River has had a most interesting history. It was originally planned to promote the development of central and western New York State, and this it accomplished. It was, however, the fear of losing control of trade with the Northwest which finally led to the beginning of actual construction. That there was much wisdom in this plan to secure control of the trade of this great territory was abundantly demonstrated as soon as the canal was completed. It resulted in the establishment of trade routes and trade relations which promoted the prosperity not only of New York State and City but of the country as a whole. And these relations have only been confirmed and strengthened with the years although they long since ceased to be closely identified with the canal itself.

Attempts, undoubtedly honest, have been made time and again to ascertain who first thought of the Erie, or as it was called in the early days, the Grand Canal. Numerous claims have been made and a mass of testimony submitted to substantiate them. Out of it all one thing seems clear. The project took form very gradually. It had earnest advocates and bitter enemies. For years other routes held the interest of the people. The final adoption of the plan by both the Legislature and the Council of Revision was by the slenderest majorities. In its behalf there are recorded instances when party men ceased to be politicians and became statesmen, when bitter political enemies fought shoulder to shoulder for the measure. It is probable that to no single person belongs all the credit for even the idea itself, but its evolution is rather easy to trace.

In the early exploration of the state it was natural that the white settlers should, when possible, avail themselves of the natural watercourses and the trails which the Indians customarily used. Following these courses and trails of the Indians the early settlers soon became acquainted with the routes into the interior. One of these followed the Hudson River and its chief branch, the Mohawk, to Little Falls, where there was a short carry, then to a point not far from the village of Rome, where there was another short carry across country to Wood Creek, and down this creek to Oneida Lake, thence via Oneida and Oswego rivers to Lake Ontario. This route gave admission to the St. Lawrence River and the Great Lakes, but communication with the western lakes was broken by the long and extremely difficult carry at Niagara Falls.

Another important water route much used by the earlier settlers was the one which followed the Hudson River, Lake Champlain and the St. Lawrence River, with carries between the water bodies. This route, of course, also gave admission to Lake Ontario, and, subject to the difficulties of the Niagara Falls carry, to the Great Lakes of the West.

From the beginning the Dutch and English settlers were on terms of fair friendship with the Five Nations, whose "long house" occupied the central and western part of the state. Through this friendship they had gained admission to the country of the Five Nations and had become familiar with the topography of the land. It was early discovered that there was an entirely feasible route between the Hudson River and the Great Lakes, which, though bordered on the south by highland, was itself but slightly interrupted. In later years it was along this route that the early emigrants to the West made their way. This plain is the one over which in the closing period of the last glacial epoch the waters dammed between the ice front at the north and the highlands of the south made a great lake. At various times its outlets and boundaries changed. During a part of its existence it overflowed to the south, and through several channels. At another time its waters found an outlet through the Mohawk and the Hudson, and it was only at a comparatively late period in its history that the front of the great northern ice sheet retreated sufficiently to allow the waters of the Great Lakes to assume substantially their present position.

It was during the time that the glacial waters which covered this plain stood at the high levels and overflowed to the south and later to the east that the broad, open valleys, now followed by our railroads, were carved out. The shifting of the waters at the various levels at which they stood smoothed the outlines of the basin, sorted and redistributed the materials, and helped to mask topographic irregularities. The net result was the great plain spoken of above.

It thus appears that as far as possible in their early trading the first settlers made use of the natural waterways, and when forced to land travel they avoided topographic difficulties. Even when the era of road building

began the roads were so bad that trade was still carried on by waterways whenever possible.

As soon as the Indian trade had developed, and more especially after the settlement of the state and country had progressed to the point where trade with the interior became an established industry, steps were taken to protect and develop the routes followed. Forts were established along the route and at the carries, and the logs were cleared from the streams. These efforts at improvement did not long suffice. Some of the more notable men of the time, real statesmen, began to dream of the possibility of a system of internal navigation. It is probable that their attention was directed to these projects by the success which had attended the construction of canals by several European countries. Even before the Revolution George Washington is credited with having formed a plan for the improvement of the Potomac. Shortly before the official close of the war Washington took a journey through New York State, as a result of which he became very enthusiastic in regard to the possibilities of improving inland navigation in the state and the whole country.

As early as 1784 the Assembly Journal takes note of a scheme "for removing the obstructions in the Mohawk River." Some little money was later spent on the project, but nothing came of it, as the legislature was unwilling that the state should bear any considerable part of the expense of development. It was in 1791 that the first canal law in New York State was passed. It directed among other things that a survey between the Mohawk River and Wood Creek* and between the Hudson River and Wood Creek should be made, and the expense of constructing the canals should be estimated. It was along the line of the survey made between the Mohawk River and Wood Creek at this time that a canal was finally constructed. As a direct result of the report of the committee having the survey in charge General Philip Schuyler was interested and later drew up a bill called "An act for establishing and opening lock navigation within this state," which was passed. Two companies were formed. The "Western Inland Lock Navigation Company" was to open lock navigation from the Hudson River to Lake Ontario and to Seneca Lake. The "Northern Inland Lock Navigation Company", was to open navigation from the Hudson River to Lake Champlain. The cost was to be met in part by private subscription, although the state agreed to share in the expense after a certain amount had been expended by the companies. Somewhat later the state assumed a large share in the expense. This was the beginning of expenditures for canal work which in total amount have now grown to a figure which staggers the imagination. According to the terms of the act the canals were to permit the passage of boats "forty feet long, twenty feet

*It must be kept in mind that there are two streams in the state named Wood Creek. One is near Rome and the other north of Fort Edward. The latter stream runs north to Lake Champlain.

wide, and drawing, when loaded, two feet." This was shortly afterward modified to permit the officers of the companies to determine the width of the locks, with the proviso that they should not be less than ten feet in width and seventy feet long.

The work of building the canal at Little Falls was actually begun by the Western Company in April, 1793, and after numerous delays it was ready for use in the fall of 1794. The report of the directors gave the following facts concerning it: Length 4752 feet, about 2550 feet of which is cut in rock; a total fall of 44 feet, 7 inches, overcome by five locks each with a lift of about 9 feet, and a minimum depth of 3 feet.

In October, 1797, the canal connecting the Mohawk River and Wood Creek was completed. It is a mile and three-fourths long, 47 feet, 6 inches wide, with two locks, one with a lift of 8 and the other with a lift of 10 feet. The minimum depth was 3 feet, 6 inches.

It must not be supposed that all this progress was made without discouragement, or unnecessary expense, for such was not the case. Nor was the success finally achieved at all brilliant. De Witt Clinton, summing the results, says: "The water improvements * * * * * * to the west were of little consequence. Two of the Portages only were surmounted, namely, at Little Falls and at Rome. That between Albany and Schenectady, and that at Oswego Falls were never touched." This partial failure marks the passing of the early attempts to improve the natural streams for inland navigation in New York State, and ushers in the period of real canal construction.

The project for an inland waterway or canal to extend from the foot of Lake Erie at Buffalo to the Mohawk River, although at first received with ridicule, gradually took form. A proposition by President Jefferson to use a part of the surplus revenue of the United States for the improvement of roads and canals prompted the New York State legislature to appoint a joint committee "to take into consideration the propriety of exploring and causing an accurate survey to be made of the most eligible and direct route for a canal, to open communication between the tide waters of the Hudson River and Lake Erie," in the hope that the general government might be induced to supply the funds.

As an outcome of the report of this committee a survey of routes was authorized, but from the report of Mr. Geddes, the engineer in charge, it was evident that the interior route had received least consideration. Enough facts were presented, however, to show that it was practicable. When approached on the matter President Jefferson showed no interest, declaring the project to be "little short of madness."

In 1810 another commission was appointed. It was at this time that the interest of DeWitt Clinton was excited, and from that time on he devoted his splendid energies to forwarding the project. The first report of the commission, in 1811, was in favor of an interior route, but proposed

that the canal be built on an inclined plane from Lake Erie east to the ridge between Albany and Schenectady, to be carried down to the level of the Hudson River by locks. The suggestion of the inclined plane excited considerable laughter, although at the time it had the support of some able engineers.

The war of 1812 interrupted all plans, but intense enthusiasm for the project was again aroused in the winter of 1815. At a meeting of prominent canal advocates in New York City a memorial to the legislature was prepared which was signed by many of the citizens of the state and city. This, when presented, had a great deal of influence in securing favorable legislation. The agitation at this time resulted in the appointment of another commission, and the making of further surveys, plans, and estimates. In February, 1817, this commission made a full and detailed report, with estimates, and on April 15 of the same year actual construction of the middle section was authorized, although it was not until April 7, 1819, that the law was passed for the construction of the canal from the westerly end of the middle section, then under construction, to Lake Erie, and from the easterly end to the Hudson River. Twelve thousand dollars for the construction of a harbor at Buffalo was also authorized at this time. In this connection it is interesting to note that "all the New York City members of both Senate and Assembly voted against the bill."

It was just west of Rome on July 4, 1817, that the first spadeful of earth was turned. The difficulties of construction were enormous, far greater than they would be found today. For the greater part of the distance west of Rome the route of the canal was through an unbroken forest. The men who had contracted to build the different sections had had no experience in such work, and they had but limited resources. Modern excavating tools had not been invented. Dependence was necessarily placed upon the pick, shovel, and wheelbarrow. As the work progressed, however, they discovered new ways of doing things, and on "October 22, 1819, water was admitted to the first section completed and the first boat sailed from Rome to Utica."

After the completion of the middle section contracts were let for the new work. Some of these contracts were for work west and some for work east of the middle section. In this the commissioners undoubtedly acted wisely, although at the time the plan was bitterly opposed. In the course of the extension of the eastern section the rights of the Western Inland Lock Navigation Company were acquired by the payment of $91,616.

The commissioners gave much attention to the selection of the route west of the Genesee River to Lake Erie, and after many surveys and much discussion a northern and slightly longer route which at no point rose above the level of Lake Erie was chosen in preference to a shorter southern

route which was in places much above the level of the lake. This choice of route made necessary the construction of a battery of locks at the point where the canal was lifted over the Niagara escarpment. These were built where the city of Lockport has since grown up.

In 1820 all but nine miles of the entire distance between Montezuma and the Genesee River was completed. In 1821 the canal between Utica and Little Falls was opened for use. In 1822 over two hundred miles of the canal were in use. In 1823 the aqueduct over the Genesee was completed, as well as all of the canal east of that river to Albany. On the 26th of October, 1825, this great canal was formally opened for navigation and the waters of the Great Lakes united by a new route with those of the Atlantic. The first boats to make the journey from Buffalo to New York carried for a whole or a part of the distance many distinguished men who had been active in promoting the construction of the canal.

The engineers' estimate of the cost of construction was $4,881,738, but there was actually expended $7,143,789.86. This increase seems to have been entirely legitimate. The original estimate, though apparently made in good faith, was undoubtedly based on insufficient information and without a knowledge of the conditions of construction as they revealed themselves during the progress of the work.

The scheme adopted for financing the canal involved, among other things, the collection of tolls. In 1820, after the opening of the first section, viz., that between Rome and Utica, $5,694.90 was collected in tolls. As the work progressed and additional sections were opened for navigation, the income from this source increased rapidly, until in 1825, the year of the opening of the entire canal for navigation, it had reached the very respectable sum of about half a million dollars.

It must be remembered that during the time the Erie was under construction work had been going forward on the canal to connect the Hudson River with Lake Champlain. This was completed in 1823, and, while not as important a canal as the Erie, it has always been regarded as a paying venture and an important link in our system of internal navigation.

Traffic on the Erie grew by leaps and bounds. The territory opened for settlement rapidly filled up, and it was not long before the people of the state began to realize that the canal would soon be unable to meet the traffic demands. Almost immediately some changes had to be made. The dirt slopes were stoned to withstand the wash of the waves and double locks were constructed in many places, but in spite of all that was done to relieve congestion at strategic points it soon became apparent that it would be necessary to enlarge the canal for its entire length. There was, however, as usual a great deal of opposition to the scheme, and it was not until May, 1835, that the work was authorized, while actual construction did not begin until August of the next year.

The failure to adopt a sound financial policy in connection with the expense of this reconstruction led to continual embarrassment in carrying on the work. In spite of this, however, it went on until 1842 when it was found that the financial affairs of the state were in such a condition that it was necessary to abandon further construction. There followed five years of earnest endeavor to restore the credit of the state, a gigantic task and one that had not been accomplished when work was resumed in 1847. During the period from 1842 to 1847 the building of railways began to attract general attention. Originally constructed for carrying passengers, the railways were finally permitted to carry freight during the months when the canal was closed, on condition that canal tolls were to be paid for the privilege. It soon became evident that a new and powerful rival had entered the field of transportation. As railway construction went on and various short lines were united the legislature was again and again requested to modify the requirements as to the payment of tolls, until finally in July, 1851, yielding to pressure, tolls on railroads were abolished. The consequences of this act were far reaching. Undoubtedly those interested in the railroads profited enormously and it is possible that the increased facilities for commerce which resulted were ample compensation to the people for loss of canal tolls. This action, however, marks the beginning of the powerful influence which railroad interests have exerted over legislation, and although financial difficulties continued to harass the legislature, all attempts to restore the imposition of tolls on the railroads failed. The work on the canals, which was resumed in 1847, dragged on until 1862, when although not actually completed it was nevertheless so declared by the legislature for the purpose of preventing the letting of further contracts. It was in this year that the canal yielded the largest revenue from tolls in its history, over $4,792,000.

The so-called completion of the work of enlargement left much to be desired. Under the guise of necessary repairs many changes were still made. No great piece of construction, however, was undertaken until 1895. In that year an act was passed which submitted to the people a proposition to issue bonds for canal enlargement, to the amount of nine million dollars. It was promptly approved, but the preliminary surveys took much time, and actual construction was delayed. The changes proposed included the deepening of the canal to "not less than nine feet of water, except over aqueducts, miter sills and other permanent structures, which might be left at eight feet." As it turned out the appropriation was not sufficient to make the changes. In 1899 the State Engineer reported an expenditure of $9,032,489.65, or $32,489.65 more than had been appropriated, with estimates for completing the work which would bring the total up to $4,800,497.53. This was a most disappointing showing, and as a result the legislature directed that existinng contracts should be termi-

nated and the contractors paid off. This was a severe blow to the friends of the canal, although it was realized that the original estimates had been altogether too low and that a tactical blunder had been committed in naming so small a sum.

The Barge Canal Act was passed during the session of 1903, and was approved by the people in November of the same year. This law provides for the expenditure of $101,000,000. The canal channel is to be 75 feet in width at the bottom, the water 12 feet deep, and the water cross sections to show not less than 1128 square feet. The channel in canalized rivers and lakes is to be 200 feet wide at the bottom, the water 12 feet deep, and the water cross sections to be not less than 2400 square feet. Locks are to be 28 feet wide, 328 feet long, with 11 feet of water. The new route follows for a considerable part of the distance the line of the old canal. A new channel is to be cut from Waterford to a point on the Mohawk above the falls at Cohoes, and the river canalized to Rome with a limited use of the old canal. From Rome it follows Wood Creek Valley to Oneida Lake, crosses the lake, follows Oneida River to Three River Point, and up the Seneca River to Crusoe Creek, from which point a new channel is cut to join the old canal at Clyde. From Clyde to Tonawanda the old route is followed with minor deviations, the most important of which is at Rochester, where an entirely new route through the city and across the Genesee River has been adopted. From Tonawanda the Niagara River is followed to Buffalo.

The plans and estimates for this, the latest, most radical, and most important of all the improvements of the old canal ever attempted, were prepared under the direction of the State Engineer, Edward A. Bond, who was later made chairman of an advisory board created by the act. This board has recently been legislated out of office as a result of changes in the political control of state affairs. Many contracts have been let for the work and a very considerable portion of it is under construction.

It is probable that the ever present fear of Canadian competition for the trade of the northwest had much to do with the adoption of the plans for a barge canal. Nor is this fear altogether groundless. The Canadian government has in recent years been very active in the construction of canals designed to make the St. Lawrence River navigable for its entire length as well as in the enlargement of the Welland Canal, and in the construction of new locks on Canadian territory at Sault Ste Marie. The Dominion government has thus planned to furnish its western provinces a cheap and convenient outlet to European markets. Undoubtedly hopes were also entertained of getting a part of the American export business. The St. Lawrence route to Liverpool from any point on the lakes west of Buffalo is approximately 450 miles shorter than by way of the Erie Canal and the Hudson River, although it is closed for a longer time by ice.

Another consideration which had considerable weight was the fact that in recent years much freight from the central and western part of our country has been finding an outlet through Gulf ports. It was feared that some of the trade which had for so long made use of the Great Lake, Erie Canal, and Hudson River route might be drawn off into the new channel. It is of great importance to the residents of the state, and more especially to the citizens of Buffalo and New York City, to hold this western trade. It is, to a large extent, a matter of freight rates. It is admitted that the railroads alone cannot hold the traffic, and it will be interesting to see whether the barge canal when completed will be any more successful. The completion of the Panama Canal will introduce another problem into the situation, the influence of which upon the distribution of Mississippi valley trade, it is most difficult to estimate.

The relation of the canal to freight rates and to the value of the goods transported has always been an interesting one. Before the days of the canal transportation was by wagon. They were huge, clumsy affairs, hauled by many pairs of horses, over roads which, poor at best, were in many places and for most of the time almost impassable. There was one road which, even in those days, was so good that it is worthy of special mention. It ran as a well-defined nantural ridge west from Rochester, and was then, as it is now, called the Ridge Road. It marked the position of the shore of glacial lake Iroquois. Inns were built at frequent intervals along the old wagon roads, "for the entertainment of man and beast," and small settlements grew up around them. As soon as the canal was built, however, most of the wagons disappeared, the old roadside inns were abandoned and the towns left to decay. The canal towns grew so rapidly and attained such importance that although the railroads passed by many of them at a distance they have never changed their location and can even now be reached from their nearest station only by a considerable walk or ride. The influence of the canal upon the early growth of our cities is less easy to measure, although it was undoubtedly very great.

Throughout the country tributary to the new canal, and all around the western lakes, the value of native products increased because of the new markets which thus became available. At the same time prices went down in the markets themselves because of the larger supplies. It benefited both producer and consumer.

After the state ceased to exact canal tolls from the railroads the competition for freight became very keen, and it was not long before the canal commissioners began to lower freight rates. This in turn forced the railroads to lower their rates. On the canal the lower rates naturally led to the use of larger boats and this in turn to the demand for larger canals, a demand which the state sought to satisfy in the ways already indicated. For the benefit of the boatmen toll rates were lowered from time to time,

until in 1882 they were entirely abandoned. On the railroads the competition led to the union of independent lines under a single management, the improvement of roadbed and equipment, the increase of power and speed, and the establishment of "through" service. On the whole it must be admitted that the existence of the canal and the facilities for transportation which it affords have had a most beeficial effect in keeping down the freight rates of the competing railroads.

In closing it may be well to remind the reader that there were many other canals built in the state, but most of them proved losing ventures and were soon abandoned. Against the Erie no such charge can be brought. It not only paid for itself and maintained itself, but it also made large contributions to the support of the state government.

A GEOGRAPHIC INTERPRETATION OF NEW YORK CITY

By F. V. EMERSON,
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NEW York is a great commercial center because here is focussed a large proportion of the foreign trade of the United States and this concentration of trade is due in large measure to geographic factors. Many other factors have been influential but seldom are the geographic factors so prominent or so easily traced as in the case of New York City.

New York has not always been the leading commercial center of North America. In colonial times it was closely rivaled by Boston, Philadelphia, Baltimore and Charleston. The city of Phildelphia led New York in population until 1810. Baltimore was the leading port of flour exports until 1825. So long as these cities were the ports of their local hinterlands, that is the country tributary to them, New York was at a disadvantage. Near New York are the Coastal Plain the Piedmont and Great Valley, productive agricultural regions, but narrow in this latitude. These belts widen to the southward and afford populous and productive hinterlands for the cities to the southward. This is especially well shown in the fact that if we include the population within twenty five miles of the city, the population of Boston about equaled that of New York in 1810 and New York was exceeded by Philadelphia until 1840. Even now the local hinterland of Philadelphia is much more productive than that of New York. These facts, by contrasting the hinterlands of New York and its rivals, bring out the salient fact of that city's leadership. New York is the most available port for a large part of North America.

It was early recognized that the city that could become the main outlet for the commerce of the Mississippi Basin would become the leading commercial center. Separating the Atlantic Slope from the Mississippi Basin are the Appalachian Ridge Belt and the Allegheny Plateau, both

difficult to cross. These belts are narrow in the latitude of New York and are broken by the Hudson Valley and a lowland extending from Albany to Lake Erie.

This lowland was utilized by the Erie Canal which in 1825 connected the Hudson with Lake Erie. The tidal Huden is joined by the Mohawk at Cohoes by a sharp rise of 189 feet, but from here westward extends a lowland of gentle grades to Lockport, a few miles east of Buffalo, where there is a rise of 60 feet to the plain on which Buffalo stands. The grades along this route are gentle except at the sharp rises before noted, the materials were easily excavated and water for operating the canal was easily obtained from the higher adjacent Allegheny Plateau and from Lake Erie.

The canal was at once financially successful and the tolls paid for the cost of construction in about twenty years. A few years later the Pennsylvania canal-railroad route connected Philadelphia with the Ohio, and, a quarter of a century later, the Chespeake and Ohio canal was completed. The cost per mile of the Chespeake and Ohio canal was $50,000 and of the combined Pennsylvania canal and railroad, $41,000; the favorable route of the Erie Canal is shown by its cost of only $20,000 per mile. None of these canals except the Erie were financially successful.

With the opening of the Erie Canal, New York became the port of an extensive and productive hinterland. The Great Lakes became an extension of the Hudson. Moreover at several points near the Great Lakes are easy portages to the Mississippi Basin. These portages were soon utilized for Canal construction and still more territory was added to the hinterland of New York. The cheaper tolls of the canals stimulated production by enlarging the market and raising prices, enhanced incomes resulted in greater purchasing power and this increased prosperity was reflected in the rapid growth of New York, the port of the region. The canal route was followed by thousands of settlers and in 1850 it was estimated that over five million persons depended on New York for much of their export and import trade. This practical monopoly of the export trade of the upper Mississippi Basin continued as long as the Lake-Canal-Hudson was the main route eastward.

But with the era of railroad building, the competitors of New York saw an opportunity to overcome the leadership of that city. The railroad can climb grades and cross divides that are impossible to canals, and the initial cost is often less. Boston was connected by rail with the Hudson by 1842. The citizens of Baltimore and Maryland pushed the Baltimore and Ohio railroad to the Ohio by 1852. Philadelphia was connected with the Ohio in 1834. In contrast with these energetic measures, New York, as a city, did comparatively little to develop railroads to her hinterland and it was not until 1851 that the railroad connecting New York and Albany was completed.

The railroad that finally connected Lake Erie to New York was not projected for that purpose; it resulted from the consolodation of local roads. These roads grew in the lowland from Buffalo to Albany in response to the dense population and to the low grades which made construction easy. The final completion of what is now the New York Central Railroad occurred in 1851 and in a few years the Erie Railroad connected New York and Buffalo.

In Ohio, Indiana and Illinois the factors of low grades, easy construction, a dense and productive population that invited the canals, hastened the building of railroads and these railroads became, in large measure, feeders for New York. That city in consequence was still, for the most part, the port of this area although not to so great an extent as in the canal period.

The Great Lakes constitute one of the best and longest inland water ways of the world and the Erie Canal made them largely tributaries to the Hudson at least during the canal period. They, have another important effect favorable to New York. Freight rates on the Great Lakes are so low that the railroads paralelling them offer, in order to meet the competition, the lowest long distance freight rates in the world. The same competition, actual or potential, had the same effect on railroads near the Erie Canal. These low rates have guided long distance freight to New York and are an important factor in making that city the greatest exporting port, especially of grain, in North America.

Other things being equal, an export port tends to become a port of imports. Ships will bring their cargoes to ports where return tonnage can be obtained. Moreover at such a meeting place of varied materials, manufacturers must spring up especially if power is easily obtained. The important anthracite coal fields of Pennsylvania afford cheap power. The commercial importance of New York often obscures the fact that the cities around New York harbor constitute the greatest manufacturing center of the United States so far as the value of products is concerned. Unlike Chicago or Pittsburgh, for example the manufacturers are not distinctive, but in their variety they reflect the variety of imports to this port.

It is probable that a great city, perhaps the greatest city, would be located at the mouth of the Hudson were the advantages of the poorest for commerce. However the local advantages give New York one of the best harbors in the world. The harbor is large enough for the navies of the world; it is deep near the shore, thus affording easy wharfage; a range of hills on the south protects from winds from that direction; the "Narrows" which connect the harbor with the sea is deep and the strong tidal scour keeps the passage way clear; the water is too salty for the easy freezing which is troublesome in some harbors.

Summary: New York has passed through two periods. Before the opening of the Erie Canal, the city's growth was a response to a relatively small and unproductive hinterland. This may be classed as the provincial stage. With the connection of the Hudson and Lake Erie by the Erie Canal, the upper Mississippi Basin was added to the hinterland. This may be called the metropolitan stage and this stage may be considered under two periods, first the canal and second, the railroad, period. During the canal period New York had a virtual monopoly of the exports of the upper Mississippi Basin. This monopoly has been less complete during the railroad period, but owing to the many converging railroads and to the competition of the lake and canal freight rates, the railroads still bring a large proportion of exports to New York. The concentration of export and import trade is an important factor in making New York a leading manufacturing city of various products. As a principal port of immigration there is a large foreign population. The harbor is almost ideal and is an important, but not determining factor, of the city's growth.

New York is a great city because it has a great hinterland. A combination of geographic factors has allowed the city to serve the people of many states.

THE CATSKILL WATER SUPPLY FOR NEW YORK CITY

By CHARLES P. BERKEY,
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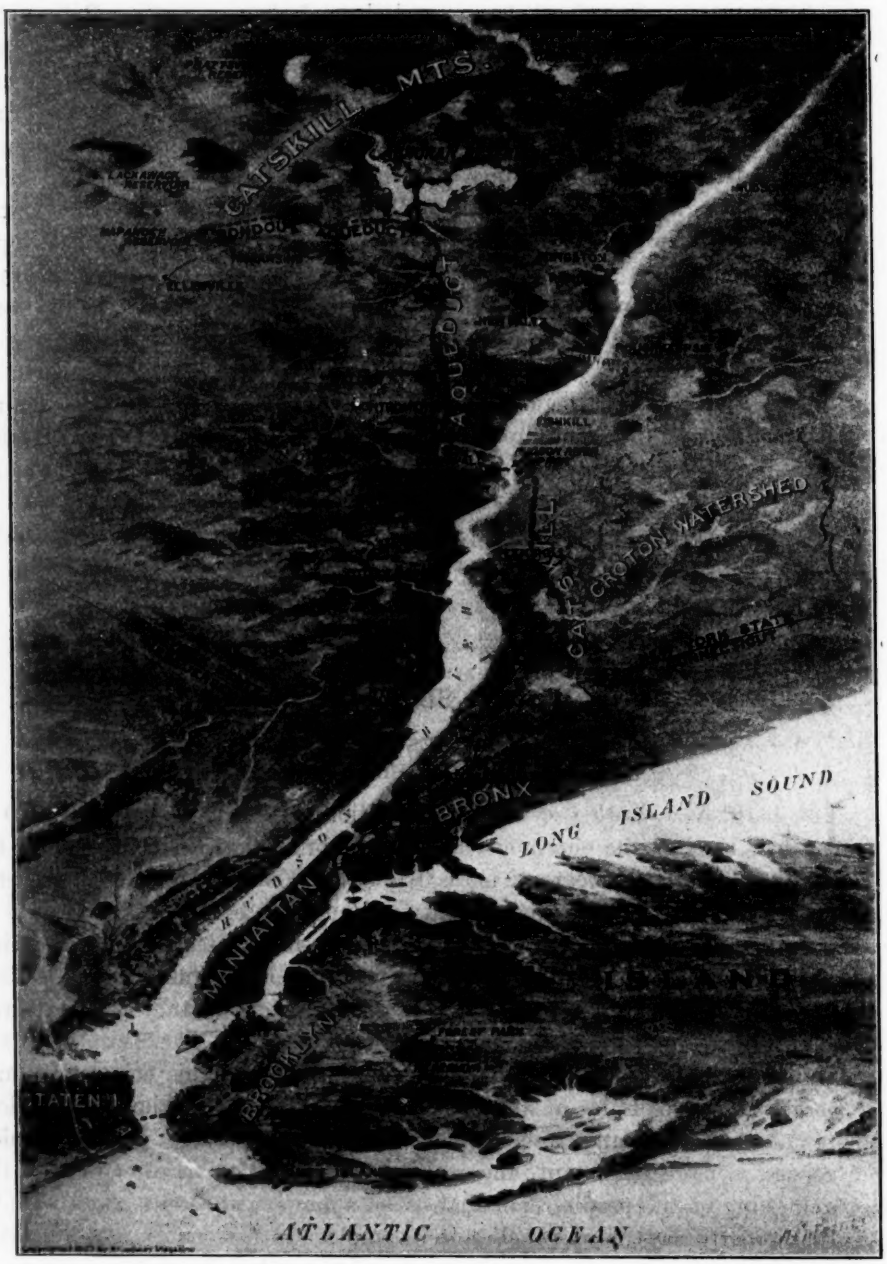
IN 1810, New York City had a population of about 96,000. In 1910 it had reached the enormous figure of approximately 4,500,000—an increase in a hundred years of more than 4,400,000, or about 4600 per cent.

During the same period the city extended its boundaries, absorbed or included many adjacent villages and suburbs, and united with neighboring cities until the area of Greater New York of today is nearly 309 square miles. The larger portion of this area is on Long Island, Staten Island and Manhattan. The main land portion is known as The Bronx. Manhattan Island is the centre of interest and activity in this community and on its 22 square miles of area dwell about 5/8ths of the whole population.

Among the many problems facing such a congested district probably no one is more important, and its successful solution more critical to the well being of the people, than that of an abundant and pure water supply. In the early days local supplies were ample and reasonably good. With increase of population many of the surface supplies were destroyed, most of the underground supplies were contaminated, and all became sadly inadequate before the half million mark had been passed. New York is so situated that artesian wells are impossible within the areas of chief population, and outside of the city geologic conditions suitable for such supplies



Birdseye View of the Lower Hudson Region showing the Principal Sources of Water for New York City (Plate loaned by the New York State Museum)

exist only on Long Island. For additional surface supplies of large amount it is necessary to go far to the north of the city where sparse set-

tlement and heavy stream run-off and suitable storage conditions may be found. The rugged country within and bordering upon the Highlands meets these requirements, as does also the still more rugged and more distant Catskill region. As time has so enormously increased the needs of the city, it has been found necessary to develop both of these sources of supply—first, the nearer one on the southerly margin of the Highlands known as the Croton system, and now, more than half a century later, the Catskill system.

It would be a mistake to infer that these are the only supplies of the city. As a matter of fact, Brooklyn and all the rest of the Long Island portion of the Greater City, as well as the whole of Staten Island, get as yet no water from the Croton system. There are many separate systems now furnishing water, most of which have developed out of independent enterprises organized before the merging of governmental interests represented by Greater New York. The most important of these supplies is obtained from wells located along the southern margin of Long Island, from which is pumped most of the water for Brooklyn.

In 1842, however, Croton River water was brought to New York through an aqueduct 38 miles long which is now known as the Old Croton Aqueduct. The supply furnished in this way proving insufficient, a much larger aqueduct 33 miles in length was constructed in 1890, which is known as the New Croton Aqueduct. Before it was finished it was clear that storage facilities in the Croton watershed were inadequate and the great Croton Dam was built, impounding 31,000,000,000 gallons of water and forming a lake 20 miles long. Other storage facilities in the Croton system amount to about 43,000,000,000 gallons. The entire Croton watershed is about 360 square miles with an average annual rainfall of 48 inches. The reservoirs now in use do not retain the total run-off by a large margin, and rainfall and stream flow is so unevenly distributed that it would require very large additional storage capacity, constructed at enormous expense, to save the total flow of the watershed. There is a limit to the economical development of storage reservoirs. Beyond a certain point the cost of such construction and maintenance may easily exceed the cost of developing an entirely new and unrelated supply. This is the stage reached in the Croton system, and when, 10 years ago the authorities, caring for the interests of the city, began to appreciate that by the year 1910 to 1912 the water needs of the city would surpass the available supply of about 547,000,000 gallons daily, they took the initial steps in the movement of constructing the new Catskill system.

In 1905 the New York City Board of Water Supply was organized for the purpose of developing the Catskill project. Two years were spent in surveying, exploring, planning and drawing up detailed specifications before any actual construction was begun. On June 30, 1907, the first sod

was tured by the then Mayor, George B. McClellan. Since that time the work has been 70 per cent completed to the city line and in the Summer of 1913 it will be possible to furnish water.

The Catskill system is to include four neighboring watersheds—that of Esopus, Schoharie, Rondout and Catskill Creeks, aggregating a total area of 750 square miles, and with a capacity to furnish over 500,000,000 gallons of water daily. Only one of these, the Esopus, is now being developed. But it is the largest (250 square miles) and most important also, because the principal storage reservoir, the head of the whole system, is in the Esopus basin. This is the Ashokan reservoir. In it will be impounded 127,000,000,000 gallons of water, forming an artificial lake 13 square miles in area, with 40 miles of shore line, and drowning the Esopus valley where it emerges from the Catskill mountains. The portion to be flooded is now occupied by the sites of seven villages. A masonry dam 1000 feet long, 240 feet high, and 190 feet wide at the base, together with flanking earth dikes and core-wall dikes of a total additional length of 3800 feet form the Ashokan dam. Additional earth dikes and core-wall dikes, across the tributary Beaver Kill Creek and other low places, reach a total length of such structure about the reservoir of nearly four miles. At its deepest point, just in front of the dam, water will stand 190 feet above bed rock and the average for the reservoir will be about 50 feet. The surface of this great reservoir when full will stand 590 feet above sea level. From it the whole 500,000,000 gallons daily supply is to be taken by an aqueduct 92 miles long to New York City. Leaving the reservoir at an elevation of 510 feet the water will flow by gravity to New York and at the Hill View equalizing reservoir on the north line of the city, will rise to the height of 295 feet. By again constructing, as a distribution conduit, a pressure tunnel 18 miles long through the heart of the city, water can be delivered under its own head to a height of 250 feet above sea level or about the equivalent of the 20th story of the sky scrapers in the lower portion of the city.

One of the features of this system is its competence to deliver so large a volume of water to so great elevation by gravitational flow. In order to accomplish this it is necessary to maintain the hydraulic head by crossing valleys under pressure so that the water will rise to about the same level after crossing. The Catskill region lies to the west of Hudson River, whereas the city to be reached lies to the east. It is necessary to cross the deep Hudson gorge and four other valleys of large size where pressure tunnels at great depth in bed rock have been made. There are, besides, fourteen smaller and shallower depressions where steel pipes laid on the surface are used to accomplish the same purpose. In addition the line crosses two mountain ranges, the Shawangunk Mountains, which are penetrated by a

single tunnel, and the Highlands, which are penetrated by a series of tunnels and other types of construction.

The aqueduct follows the surface elevation and contours of the country wherever practicable—that is, wherever it is nearly the same as the hydraulic grade. This permits the simplest form of construction—the so-called cut-and-cover type. It is essentially a trench of so nicely adjusted gradient that the water can flow in it toward the city. In the Catskill system this trench is not left open, however, it is completely enclosed in concrete, thus forming a great concrete tube. The regular aqueduct section is about 15 feet in diameter and whether through rock or on the surface is everywhere lined heavily with concrete. Where only small depressions are reached the aqueduct line is swerved around them and kept at grade. But wherever this would require too great and expensive a detour some method of crossing the depression under pressure is employed. The shallower places permit of the use of steel pipes—three parallel pipes 8 feet in diameter being required to carry the full aqueduct flow. Wherever deep and wide valleys have to be crossed, deep rock tunnels beneath the valleys have been made and the waters plunge down vertical shafts from 500 to 1100 feet deep, and are led through a tunnel to the opposite side where the water rises again in a similar shaft to hydraulic grade. Wherever mountains or other elevations are reached they are tunneled through at grade.

The aqueduct leaves Ashokan at an elevation of 510 feet above sea level. It crosses Esopus Creek in pipes, follows the contours of the valley side at grade for several miles and reaches its first large depression, the Rondout Valley, at about 490 feet elevation and about 300 feet above the floor of the valley. Here a tunnel 4½ miles long is constructed beneath the valley deep enough to avoid all influence from surface irregularities, some parts reaching 250 feet below sea level or over 700 feet lower than the aqueduct grade. On the east side of the valley the water rises again to hydraulic grade, about 480 feet above sea level, and is carried through the Shawangunk mountain range in a tunnel at that level and emerges in the Wallkill valley where the same pressure tunnel construction is required. Many miles of cut-and-cover aqueduct then carry the water to the Moodna Valley where again a long pressure tunnel is used.

No feature of the whole project has appealed to the public so much as the crossing of the Hudson, although as a matter of fact the Rondout Valley crossing presented much greater variety and more real difficulty. The Hudson is a drowned valley. Furthermore, like other valleys and former channels of other streams, it is partly filled with Glacial drift. Continental depression since the Glacial epoch has not favored the removal of this debris. At no point below Albany, 150 miles from the sea, does the river flow on bed rock, and at no point in that whole distance is the precise depth of the rock channel known. Explorations in the river at the point

finally chosen for the crossing at Storm King, the northern margin of the Highlands, indicated a depth of at least 765 feet below water level. Inclined borings from the banks indicated that solid rock exists at least as high as 950 feet below sea level. In order to avoid any possible difficulty that might arise in a too shallow tunnel the depth finally chosen for the pressure tunnel was 1100 feet below sea level. Two shafts over 1100 feet deep lead down to it, and the whole is now nearly completed. The Catskill water comes to the Hudson with a head of 400 feet and rises to that height on the east side when it is to be led off again by grade tunnel through Breackneck Mountain and Mount Taurus on its journey through the Highlands.

Twenty miles north of the City, just above White Plains, Kensico, storage reservoir is being constructed as a link in this system. It will hold 40,000,000,000 gallons, enough of which will be available for 30 days' supply. This will serve as a fair emergency margin. Hillview equalizing reservoir will hold 900,000,000 gallons, all of which will be available. It is intended to equalize the flow and the reservoir level will not be expected to fluctuate a great deal but in case of extreme emergency there will be nearly two days supply.

Of the many complicated engineering and geological problems involved there is not space to tell. All of the engineering details of importance are made available in the Annual Reports of the Board of Water Supply. The geological problems with an account of the results of explorations are given in Bulletin 146 of the New York State Museum entitled: "Geology of the Catskill Aqueduct."

The whole system when complete will include:

6 miles of steel pipe.
13½ miles of tunnel through mountains at grade.
18 miles of pressure tunnel below grade.
54½ miles of cut-and-cover aqueduct.
10 dams.
10 impounding, storage, and equalizing reservoirs.
4½ miles of dikes.
1 filtration works.
18 miles of distribution pressure tunnel in New York City.
16 miles of distribution pipe lines in New York City.

And it will have required the making of 58 deep working shafts in pressure tunnel construction whose aggregated depth is more than 4 miles.

The total cost was estimated at $176,000,000 and the estimates have not been exceeded in the work thus far completed. It will take several years longer to finish the whole system, but the most critical portions are already so far along that it will be possible to add water to the Croton system, if necessary, next year. The additional supply comes none

too soon. In the early autum of 1911 the apparent storage supply in the Croton system was estimated to be sufficient for only about a month. Strenuous measures were taken to cut down waste and to guard all supplies of the city. The Summer season had been abnormally dry and a water famine was a certainty unless normal precipitation should relieve the long drought. Heavy rains came in October, storage reservoirs are now replenished, and the danger is probably permanently averted, for, unless the Summer season of 1912 shall prove to be still more abnormally dry the Catskill supply will reach the city before the next return of such conditions. When the system is completed New York City will have doubled its water supply and will be able to use daily more than 1,000,000,000 gallons of most excellent water.

A FEW THINGS THAT EVERY NEW YORK PUPIL IN GRAMMAR GRADES SHOULD KNOW

By AMOS W. FARNHAM,
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I. *Regarding latitude and longitude*: That the northern boundary of New York extending from the St. Lawrence River due east is the parallel of forty-five degress north latitude, which means that this boundary is due north from the equator a distance of forty-five degress of latitude. Since the north pole is ninety degrees distant from the equator then every point in the forty-fifth parallel of north latitude is midway in latitude and nearly midway in distance between the equator and the north pole. The parallel of forty-five degrees north latitude is also the northern boundary of Vermont, Wyoming, and Yellowstone National Park. The southern boundary of New York that extends east-west is the parallel of forty-two degrees north latitude. This parallel is also the northern boundary of California, of Nevada, and of a part of Utah.

The meridian of seventy-four degress and three seconds west longitude passes through the City Hall of Greater New York; the meridian of seventy-three degrees and forty-five minutes through Albany; and the meridian of seventy-eight degress and fifty-five seconds through Buffalo.

II. *Standard Time*: Sun time for all the people of New York even would cause much trouble and more confusion. Hence our country with other civilized countries has adopted a system of standard time. People have considered all places in any standard time section as having the same longitude from Greenwich; fifteen degrees, thirty degrees, forty-five degrees, and so on, so that the difference in time of Greenwich and any given place shall be in whole hours, and the difference in time of any two given places shall be in whole hours. The meridians which govern the standard time sections of the United States are the seventy-fifth, the ninetieth, the

one hundred fifth, and the one hundred twentieth. New York has the time of the seventy-fifth meridian, hence all places from New York City to Buffalo have the same clock time, which is five hours earlier than Greenwich time.

III. *Light and Heat*: Nearly all our light and heat come from the sun. The angle formed by the sun's ray and an exposed surface is called the angle of insolation. The more nearly the angle approaches a right angle the greater the degree of insolation. It follows then that anywhere outside the tropics, hence anywhere in New York State, the southern slopes receive more heat than slopes of any other direction or surfaces lying in a horizontal plane. Not only the *angle* of insolation but the *duration* of insolation (length of day) determines the degree of insolation. The angle of insolation at Malone is farther from a right angle than it is in New York City. But Malone has a longer day. Each city loses in one respect and gains in another. These differences would be more apparent if the places considered were farther apart, as Montreal and New York City.

Temperature is not heat; it is the degree of heat, and is measured by the thermometer. Places having the same degree of heat may be connected by lines called isotherms. Hence the temperature of any region may be mapped.

IV. *Rainfall*: Rainfall is governed by certain laws.

(1) Rainfall decreases as latitude increases.

(2) Rainfall increases as altitude increases up to a certain height and then decreases. The "certain height" decreases as latitude increases.

(3) Rainfall is greater on the windward side of mountains than on the leeward side.

(4) Rainfall is determined by (a) nearness to large bodies of water and the temperature of their surface waters; (b) the direction of the prevailing winds, and (c) the relief (elevation and surface undulations) of the region. The warmer the atmosphere the greater its *capacity* for water vapor.

A wind moving southward is increasing in temperature, hence increasing in capacity for water-vapor and is therefore a moisture-gathering wind. A wind moving northward is decreasing in temperature, hence decreasing in capacity for water-vapor and is therefore a moisture-giving wind.

A wind to cross a mountain range must rise; as it rises it expands (because of diminished air pressure); as it expands it cools; as it cools it gives its temperature to the water vapor which it carries; as the water vapor cools it condenses and falls as rain (or snow) on the windward side of the mountain range. As the wind reaches the crest of the range it descends (due to the pull of gravity); as it descends it condenses; as it condenses its temperature increases, hence its capacity for water-vapor increases and it becomes a moisture-gathering wind.

V. *Topography*: New York has every kind of geographic form except desert; and even deserts of limited areas are represented by the sand dunes of the eastern shores of Lake Ontario, of Long Island, and Central New York. New York is rich in mountains, plateaus, valleys, plains, islands, lakes, streams, water-falls, canyons, and caverns. The highlands culminate in Mt. Marcy and Whiteface, peaks of the Adirondacks, whose heights are respectively 5,345 feet and 4,870 feet above sea level. The valleys, especially the Hudson and the Mohawk, have furnished material for song and story. The Thousand Islands and Niagara Falls are known throughout the civilized world, for their beauty and grandeur. The canyon (chasm) of the Au Sable is one of the most remarkable of the kind east of the Rocky Mountains. The quiet beauty of the Finger Lake Region attracts thousands of vacationists every summer. The continental glacier that moved over nearly all the area included within the boundary of New York added to the picturesqueness of the scenery. The local hills are glacial deposits, either drumlins, kames, eskers, or moraines. Nearly all the lakes and water-falls of the state and the soil as well had their origin in the glacier.

The relief is shown on maps by means of contours. A contour is a line that represents the location of places of equal altitude.

VI. *Industries*: New York takes high rank in every one of the seven great industries. She leads the states in the production of hay, potatoes, hops, milch cows, milk, and cheese. Greater New York consumes 1,500,000 quarts of milk and cream daily. Eighty-seven per cent of this supply comes from the state of New York. New York is second only to Iowa in the production of dairy products. The first cheese factory was built in 1851 in Oneida County and the first creamery in 1861 in Orange county.

New York leads the states in the development of electrical energy by water power. New York city makes one-tenth of all the manufactured products of the United States. No other American city approaches New York in the printing and publishing industry. The various interests centering in New York make it the financial and banking center of the entire country.

New York is the leading commercial center of the Union. "From Tappan Sea to the mouth of New York Bay probably a greater number of vessels ply than can be found on any other river in the world." New York harbor is the finest harbor of the American Continent.

VII. *Schools*: The first New York school-master was Adam Roelandson. His school was a private school which he opened in 1633. "Adam" came from Holland in company with Wouter Van Twiller, the second governor of the New Netherland colony. We are told that the school-master "soon made himself a thorn in the side of about everybody else."

Soon all his pupils left him and he was compelled to look elsewhere for his living. So he became a "washerman."

Two private schools were opened in 1645. Both schools prospered. The price of tuition for one year was "two dried beaver skins."

Through the efforts of Governor Peter Stuyvesant the first public school in America was opened in a building on Pearl Street, April, 1652. "A very able and highly educated gentleman, Doctor La Montague, was the first teacher, and he gave his services without pay. One of his successors received a salary of fourteen and one-half dollars a month, with an extra allowance of fifty dollars a year for his board."—From *The Making of the Empire State.*

In 1754 was founded King's College which in less than thirty years became Columbia College, now Columbia University. In 1795, for the first time, the legislature gave a small sum of money towards the support of schools. In 1813 the state determined to take charge of the schools, and to aid in carrying out the work a State Superintendent of Public Instruction was appointed. Governor DeWitt Clinton, the man who helped New York State to the Erie Canal, never lost an opportunity to speak in the educational interests of the boys and girls. He appealed "for free schools, for better schools, for well-educated teachers, and well-trained, broad-minded boys and girls." Free schools were not fully realized until 1867.

"We are apt to look upon war as a great horror, as indeed it is. But war is less horrible than ignorance; lack of patriotism and wide-spread dishonesty are vices that are even more deadly to a nation than war. If people become forgetful of the debt they owe their country—if they forget that self-government requires intelligent thought, absolute honesty, and the sacrifice of self, they need to be promptly shaken into a sense of their duty. And if a war is the only thing to stimulate them to duty, the quicker it comes the better. Indeed, there is one warfare that should always keep the people of a nation in arms—the warfare against ignorance, dishonesty, and vice. And if the State of New York is to remain the Empire State in years to come, it will be, not because of her great wealth and wonderful resources, but because of the industry and integrity of the men and women who are now boys and girls in her schools."—*Jacques Wardlaw Redway.*

VIII. *The Empire State*: New York is called the Empire State because she leads the states of the Union in population, manufactures, commerce, and wealth. That she may train her youth to become efficient citizens she spends about thirty-five million dollars annually on her public schools.

THE DEVELOPMENT OF BUFFALO

By P. F. PIPER,
Buffalo High School

THE industrial development of the section known as the Niagara Frontier is due directly to its favorable physiographic environment.

The stream of immigration which flowed westward through the Mohawk valley expanded over the fertile lowlands and the plains which lie beyond the water-gap at Little Falls; it overflowed the low divide near the present city of Rome and reached Lake Ontario by way of Oneida Lake and the Oswego River; the rapids and the great cataract at Niagara and the bold escarpment near the present village of Lewiston checked the westward movement of the population. Gravity is an important determining factor in the location of centers of civilization.

The Lewiston escarpment, more than 200 feet high, separates the plain along Lake Ontario from the cuesta-like plain which extends to the south, along the shores of Lake Erie. An ancient Indian trail up the cliff was later developed into a wagon-road, which made a tedious and expensive climb for the early pioneer. The fertile fruit lands along the shores of Ontario were soon settled and a check was given to westward immigration until the rich valleys of Central New York were taken up. Soon the Albany Turnpike was extended to the shores of Lake Erie, the tiresome stagecoach gave way to the fast packet-boats on the Erie Canal, which were later followed by the steam railroad. The stream of immigration increased, rapidly becoming a flood rushing down the gently sloping plain to the shores of Lake Erie, forming a great human delta at the junction of Buffalo Creek and Lake Erie. The equable climate, tempered by the waters of the lake, was milder in winter and cooler in summer than adjacent sections, and along the Niagara Frontier arose the fruit-and grape-belt for which western New York is famous.

The original harbor of the port of Buffalo was Buffalo Creek, a sluggish stream but a few rods wide, swinging in wide meanders across a low, alluvial plain but slightly above the level of Lake Erie. In its original condition the entrance channel from the lake as shallow and frequently closed by a gravel bar through which the Federal Government has dredged a channel 23 feet deep and more than 200 feet wide, extending 2,200 feet into the lake. A breakwall in four sections having an aggregate length of 22,603 feet extends parallel to the shore, making an outer harbor more than a half mile wide and four and one half miles long, where the largest vessels may ride at anchor safely. "Glasgow made the Clyde, and the Clyde made Glasgow." So it may be said of Buffalo.

Thirteen steamship lines have terminals at this port. "In a single year there were 7000 arrivals and clearances of lake vessels, having a tonnage

of 14,500,000 tons, exceeding that of Liverpool and making Buffalo one of the ten great ports of the world," despite the fact that navigation is closed by ice for four months every year. "No other island navigation in the world" says Brigham, "compares with that of the Laurentian Lakes, and what it may become in the century just begun, it would be rash to foretell."

"Buffalo is the great doorway of the Inland Seas. Some day she will reach out to the ocean, and when that time comes, she will become one of the greatest cities in the world." These prophetic words were spoken by President McKinley a short time before his death. Today the Empire State is enlarging the Erie Canal into a waterway capable of carrying barges of 1,000 tons capacity. An additional appropriation of $20,000,000 for the development of terminal facilities was authorized by the voters of the state at the last election, making a total appropriation for canal improvement of $121,000.000. This figure does not include the appropriations made by the Federal government for breakwater, locks and dredging at Buffalo.

The present Erie Canal has a depth of from seven to nine feet and is 52½ feet wide at the bottom. The New Barge Canal will have a uniform depth of twelve feet with a minimum bottom width of 75 feet, making the new canal capable of carrying boats 150 feet long, 25 feet beam, and a draught of 10 feet, giving a capacity of more than four times that of the boats now in use.

It is claimed that grain will be carried from Buffalo to New York for one cent a bushel—two and one-half cents less than the current price. In 1911, the total grain receipts at this port were 115,686,692 bushels. It is stated that freight of all kinds, including iron, steel and manufactured products will be carried from Buffalo to New York at 26c the ton, less than ⅓ the present price. The importance of this fact has great significance, for at the present time Buffalo is producing iron and steel 65c a ton cheaper than Pittsburg. A single steel-making plant located here has from six thousand to ten thousand persons on the pay-rool of the corporation. Limstone is found within a few miles of the plant and a constantly increasing amount of iron-ore is entering the port to be converted into steel or pig iron. Buffalo has become a great distributing point for coal, which can be purchased for $1.60 to $2.00 a ton. Ninety per cent of the coal which passes through the Detroit river is shipped from Buffalo.

The iron-ore docks and copper mines of the Lake Superior region, and the important grain and lumber centers of the Great Lakes are within one thousand miles of Buffalo. "Seventy-five per cent of the flour and ninety-five per cent of the wheat came to Buffalo; also seventy-five per cent of the corn, ninety per cent of the flaxseed, and ninety-five per cent of the barley. In other words, Buffalo may be regarded as almost the only receiving port on the lakes for western grain."

The lake trade has become an enormous business. The old type of vessels of wood construction have become obsolete, the whalebacks are gone, and the small iron ships are being displaced by steel freighters from five hundred to six hundred feet long. As this is being written, January, 1912, a steel vessel has been launched which is 627 feet long, capable of carrying possibly a half million bushels of grain in a single cargo. The grain elevators at Buffalo have a capacity of some 25,000,000 bushels, sufficient to store the surplus grain which cannot be unloaded directly into railroad cars or canal boats. The elevators of wood construction have been replaced by great steel cylinders set on end into which the grain is transferred by electrically operated buckets on endless belts. Here the grain is kept dry, clean, vermin-free and relatively free from danger of damage by fire. More than four million barrels of flour were milled in the Buffalo district in 1910. The total grain receipts in the same year were 102,071,175 bushels.

Seventeen railroads including the great trunk lines, enter the city. There are no difficult engineering problems to be overcome for the region is a plain but slightly dissected by streams. The total tracks within the city are some 500 miles in length, including the tracks which carry the live-stock. In a single year 26,000 cars of cattle, hogs and sheep were received either for slaughter locally or for reshipment. More than 1,000 carloads of horses were received in the same period. In 1910 the railroads brought to the Buffalo lumber market 284,653,976 feet of lumber, thus maintaining the supremacy of Buffalo as the lumber center of the world. (The facility of railroad service is shown by the following:)

"Sixty acres of floor space now comprises the area of the Larkin soap plant. Fourteen and a half acres have just been added by the completion of a new terminal warehouse. This is connected by steel bridges with the main plant. By means of conveying systems products will be carried directly from producing room to packing room, thus reducing hand-trucking to a minimum. This new terminal building is one of the largest structures devoted exclusively to packing, shipping and storage. The cars will be loaded in the warehouse where, on the first floor, four railroad tracks enter and run the entire length of the building. These tracks have a capacity of sixty cars. Here the consignments will be shipped out on the seventeen railroads. The new building is 580 feet long, ten stories high and is built of steel reinforced concrete."

Today more than a half million persons have their homes along the Niagara River between Lake Erie and the cataract at Niagara. The great waterfall has been harnessed, and more than 300,000 electrical horsepower has created a new industrial electro-chemical wonderland along the shores of the Niagara, where are made aluminum, carborundum, graphite, acids and calcium carbide. Nitrogen is stolen from the air to be used as a fer-

tilizer, and cereal foods, flour, silverware, soda ash, and paper are manufactured.

Great dynamos capable of generating 5,000 or more horsepower transform the energy of the falling water into power which is transmitted as far east as Syracuse, New York. Buffalo is using a large quantity of Niagara power. But before it reaches the long-distance transmission wires, it must go through what is known as a "stepping-up" process. This is made necessary by the fact that the current is generated at only 2,200 volts. At that voltage it would be impracticable to transmit it to Buffalo, twenty-five miles away, so the transforming devices increase, or step-up, the voltage to 22,000. Line losses aggregate twelve per cent in the journey to Buffalo. The voltage however remains the same, 22,000 until the current reaches this city when it is stepped-down, first to 11,000 and then to commercial pressure. Some of the current is transformed to 350 volts and the rest to 2,200.

To these commercial advantages must be added a delightful climate and the beautiful scenery along the Niagara River, which combined make Buffalo the Queen City of the Great Lakes.

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